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## (54) IMPROVEMENTS IN COMPONENTS USING CAST-IN COOLING TUBES

(71) We, JAMES BROWN & SONS LIMITED, a British Company, of Commercial Street, Middlesbrough, Teesside, TS2 1QA, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in the cooling or rate of heat transfer between a casting and a coolant or substance to or from which heat is being transferred.

In the manufacture of castings which have to transfer heat it is common practice to cast the metal around a tube through which a liquid or gas can be passed. The tube may be shaped to suit the form of the casting and situated where the maximum heat transference is required. The tube in this way forms a passage which will not leak irrespective of the soundness of the casting and may provide a conduit of a shape which could not be achieved by normal casting techniques using cores.

The use of a plain tube has disadvantages in that it is difficult to achieve fusion or even intimate contact of a large proportion of the surface area. This significantly reduces the efficiency of heat transference. A plain tube can, in some instances, be the cause of large defects in the casting which result in a very low local heat transference and casting weakness.

According to the present invention we utilise an externally ridged tube having an external surface area which is between  $2\frac{1}{2}$  and 5 times the external surface area of a plain tube having an external diameter which is the same as the minimum external diameter of the ridged tube between the ridges. We have found that by this means the efficiency of heat transference can be raised and in some instances the casting defects adjacent to the tube reduced or eliminated. The ridging may take the form of external fins, or a corrugated tube may be employed.

The manner in which this improvement is achieved is due to the increased area of contact between the tube and the cast metal. Furthermore thin wall tubes made of a poor conductor such as stainless steel can be used, even in cases where the contraction of the cast metal is greater than that of the tube; in such cases the use of an externally finned or corrugated tube results in intimate mechanical contact over an area much greater than that achieved when a plain tube is used.

For example, if a high conductivity tube of copper is to be cast into a copper alloy bearing, it is necessary to cool the tube to prevent it melting when the metal is poured around it. With this improvement a thin wall corrugated tube of stainless steel would withstand the molten metal and reach the same temperature thus cooling at the same rate as the casting. In addition, as the tube can reach the temperature of the molten metal, defects due to gas or inclusions are less likely to be trapped against the surface of the tube. It has also been found that the thin corrugated tube facilitates fabrication as it can very easily be bent to the required form.

A further feature of the invention resides in the use of internal means for improving heat exchange by modifying flow conditions; without this full potentiality of the invention will not be realised, as a temperature gradient may build up across the cross-section of the coolant, limiting the degree of heat transference from the wall of the tube. In the case of a corrugated tube, the corrugations themselves not only modify the flow but provide a greater surface area than a plain tube, thus increasing the cooling efficiency in more than one respect. In the case of an externally finned tube, the said internal means may consist of internal fins.

Another problem is this: it is accepted that, in the case of water-cooled copper components used in blast furnace construction, it is necessary to have an efficient cooling system to

avoid the components being melted or damaged by the heat to which they are exposed. It is also accepted that there are certain advantages to be gained by having more than one chamber within the component so that in the event of damage to the front portion the water can be shut off without affecting the rear chamber.

In the case of blast furnace tuyeres it has been found convenient to use a pipe cast into the nose to act as a separate chamber, but if a plain tube is used it is necessary to select a high conductivity material such as copper. However, the internal surface has of necessity a small area compared with the surface of the tuyere exposed to heat, resulting in inadequate cooling of the nose area. To ensure that the copper tube does not melt when the casting is made it has to be cold and consequently there is a degree of danger in the casting operation and defects due to gas or inclusions tend to be trapped by the rapid solidification of copper against the cold tube. The voids, inclusions and the lack of intimate contact between the cast copper and the tube reduce the thermal transfer between the cooling water and the cast copper.

The quality and the area of contact between a finned tube and the cast copper in the nose of a tuyere is sufficient to allow use of a lower conductivity material such as cupro nickel which does not require cooling during the casting process as it withstands the temperature of the surrounding copper, thus ensuring the higher quality at the area of contact.

The invention is illustrated by way of example in the accompanying drawings wherein:—

Fig. 1 is a section through a water-cooled bearing;

Fig. 2 is a view on the arrow A of Fig. 1; Fig. 3 shows a detail of Fig. 2 on a larger scale;

Fig. 4 is a section through a water-cooled tuyere for a blast furnace; and

Fig. 5 is a section through the line B—B of Fig. 4;

The water-cooled bearing of Figs. 1 to 3 consists of a copper alloy material 10 presenting a part cylindrical bearing surface 11 (which may subsequently be lined with white metal or another bearing material if desired) which has been cast round a thin wall corrugated tube 12 of stainless steel. The corrugations of the tube 12 are not shown in Figs. 1 and 2 but can be seen in Fig. 3, and it can be seen from this figure that the corrugations form ridges 13 and pockets 14 inside the tube (which prevent laminar flow conditions) equivalent to pockets 13 and ridges 14 on the outside of the tube. This corrugated tube has about  $2\frac{1}{2}$  times the surface area of a plain tube and can easily be bent to the required convoluted form.

The corrugations may provide a series of pockets and ridges lying at right angles to the length of the tube, i.e. in the form of concentric rings, or they form a single or multi-start helix.

The water-cooled tuyere of Figs. 4 and 5 is of generally known type formed by casting copper alloy round a circular cooling tube 15 in the nose 16 of the tuyere, and an inlet pipe 17 and an outlet pipe 18 communicating with the tube 15. A water chamber 19 in the main body of the tuyere has an inlet and outlet (not shown) for cooling water, and the nose 16 is cooled separately through the pipe 17, the tube 15 and the pipe 18.

The feature that distinguishes the tuyere of this example from the prior art is that the tube 15 is of cupro nickel and is externally finned, as shown in Fig. 5. The tube is also internally finned, to improve still further the heat transference. The pipes 17, 18 may also be of cupro nickel but, as no heat transfer is necessary to and from these pipes, finning is not required.

The same principle can be applied to other water-cooled cooling elements used on blast furnaces, and it will be appreciated that a corrugated tube can be used in place of a finned tube.

The invention is, of course, not limited to the particular metals and combination of metals referred to above, as any suitable materials can be used.

#### WHAT WE CLAIM IS:—

1. A metallic casting of the type comprising a channel for the circulation of a cooling fluid said channel being defined by a metallic tube embedded in the casting, said tube having ridged internal and external surfaces, the external surface area of said tube being between  $2\frac{1}{2}$  and 5 times the external surface area of a plain tube having an external diameter which is the same as the minimum external diameter of the ridged tube between the ridges.

2. A casting according to claim 1 wherein the ridges take the form of fins.

3. A casting according to claim 1 wherein the ridges on both surfaces are formed by corrugations in the tube.

4. A casting according to claim 3 wherein the tube is a thin-walled flexible corrugated tube.

5. A casting according to any one of the preceding claims wherein the tube is made from stainless steel.

6. A casting according to any one of the preceding claims wherein the tube is made of a copper/nickel alloy.

7. A casting according to any one of the preceding claims wherein the metal cast round the tube is copper or a copper alloy.

8. A casting according to any one of the preceding claims in the form of a water-cooled cooling element for a blast furnace.

9. A casting according to any one of the preceding claims in the form of a tuyere, the tube being in the nose of the tuyere.
10. A casting according to any one of claims 1 to 7 in the form of a bearing.
11. In the manufacture of a casting having a tube embedded therein, the improvement which consists in casting metal round a tube having ridged internal and external surfaces, the external surface area of said tube being between  $2\frac{1}{2}$  and 5 times the external surface area of a plain tube having an external diameter which is the same as the minimum external diameter of the ridged tube between the ridges.
12. The improvement according to claim 11 wherein the tube is made of stainless steel.
13. The improvement according to claim 11 wherein the tube is made of a copper/nickel alloy.
14. The improvement of any one of claims 11 to 13 wherein the metal cast around the tube is copper or a copper alloy.

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